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NOTES RELATING TO THE GYMNOSPORANGIA ON MYRICA AND COMPTONIA

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(With Plates 2 and 3, Containing 9 Figures)

The only species of rust on the sweet fern heretofore reported is the *Cronartium* that has its *Peridermium* stage on the pines (Clinton, 1908; Orton & Adams, 1914). This rust was described by Arthur (1906) from material collected at Egg Harbor, New Jersey. It was quite abundant at Toms River, New Jersey, in September, 1915, where it was found by members of the party on the excursion conducted by the Torrey Botanical Club during the Twentieth Anniversary Celebration of the New York Botanical Garden.

During the spring and summer months of 1916, the writers, Professor Harper, and others made several trips into the pine barrens of New Jersey to gather data bearing on the life-histories of the species of *Peridermium* and *Gymnosporangium* to be found in this region. On June 14 we found that certain plants of *Comptonia* bearing *Cronartium Comptoniae* were also infected with some other rust whose spermogonial stage was just becoming evident. As no aecidium had been reported on this host, it was decided to make another visit to this spot a few weeks later to obtain mature specimens.

On July 4 we found a number of leaves and young shoots bearing ripe aecidia, and spores were being shed quite abundantly. The only leaves found to be infected June 14 were very young, some of them scarcely unfolded from the bud. The hypertrophy induced by the rust is not definitely limited, but is general and extends along either side of the midrib beneath, making the leaf quite thick and brittle.

As only a slight yellowish discoloration accompanies the infection, this stage of the rust is easily overlooked. We also found spermogonia on pistillate catkins, which were of a darker orange color. We were unable to find aecidia on these burs later.

The aecidia on the leaves and young stems appear to be scattered rather sparingly over the long hypertrophied or thickened portions. A marked transformation of the leaf seems to accompany infection. Every leaf that we found bearing aecidia had made a coil of one or two turns like a ram's horn, which, in a way, quite effectually conceals the rust from view. *Roestelia transformans* was originally described as causing considerable deformation of the *Aronia* leaves, yet a great many leaves infected are in no way misshapen. Further collections of this rust on *Comptonia* may prove that it does not always cause the leaf to roll up. The peridia are whitish, with very brittle segments which soon disappear, or break off and become scattered over the under surface of the leaf. The spores are globoid, varying in size from 25–35 μ. They appear to be rather dark-orange or salmon-colored in mass. The spore wall is finely warted or echinulate. This rust resembles *Aecidium myricatum,* known so far to occur only on the bayberries. *Cronartium Comptoniae* has been found also on species of *Myrica,* and it is not surprising to find that a *Gymnosporangium* capable of infecting *Myrica* could also infect *Comptonia* as the two genera are closely related.

Fromme (1914) has shown that *Aecidium myricatum* is connected with *Gymnosporangium Ellisii* on *Chamaecyparis.* In 1914 Dodge (1915) tried to infect *Comptonia* with *G. Ellisii* without success. The trial host plants lived only about two weeks after the inoculations were made, but as the rust appeared on the *Myrica* within a week it was presumed that this *Gymnosporangium* would not infect the sweet fern. The teleutospore material used at the time was in the best of condition, so that failure was not on this account. We made some attempts to infect the sweet fern with the spores of *G. Ellisii* under controlled conditions in the greenhouse, but the season was so far advanced that the sweet fern could not be made to survive transplanting, and the spores of *G. Ellisii* were past their prime.

Aecidium myricatum on the bayberry is especially abundant at Toms River; in places the rust appears to be destructive, especially where it attacks the branches or main stems. The southern white cedar and sweet fern grow together in many localities along the coast, but we have found the sweet fern rust only at this one place, which is just across the bridge near "the bird-house establishment" at Toms River. Even here it is rare. If the rusts on the bayberry and sweet fern belong to the same species, it is interesting to note that the host reactions are somewhat different in the two cases.

The aecidia on the *Myrica* are ordinarily very closely crowded on rather definitely limited thickened areas (Pl. 2, f. 1–3). Infected sweet fern leaves are shown in Pl. 3, f. 1–4. The coiling of the leaves resembles somewhat the effect of insect work, especially such as one sees on sweet fern plants. The aecidiospores from the two hosts appear to be identical so far as size and wall characters are concerned. It is possible that they are darker colored in the rust on *Comptonia.* Our photographs (Pl. 2, f. 3, 4) show that the peridial segments may be more persistent and more recurved in the *Myrica* rust. This may have been due to the difference in the atmospheric conditions prevailing at the times the photographs were taken. Fromme (l. c.) found that spores of *Aecidium myricatum* had seven or eight germ pores. Professor C. R. Orton has kindly examined our specimens of the rust on *Comptonia* and *Myrica* and finds that the peridial cells and aecidiospores are the same in both forms, although the number of germ pores in the spores of the rust on the sweet fern was not determined.

We have made a number of inoculation experiments with *Aecidium myricatum* from *Myrica* with the view to determine the conditions under which the *Chamaecyparis* may become infected. Eleven potted cedars were sprayed with aecidiospores on June 21, 1915, and kept in a moist chamber two days. The plants were then stacked in the greenhouse under bayberry plants heavily infected with the rust. The cedars were sprayed twice each day during the time spores were being shed from the rusted bayberry plants. As yet there are no indications of infection. Reed and Crabill (1915) have raised the question in connection with the infection of red cedars by the apple rust whether it may not be that the aecidiospores winter over and infect the cedars in the spring. Just why this is assumed or thought possible is not clear in face of the fact that they show in tables of germination experiments that spores germinate in cultures to the extent of 12 per cent. in some cases during July.

We have shown that the percentage of germinating spores in our cultures of *Aecidium myricatum* is very low, yet one can find germinating spores in the drops of water on the leaves of cedars that have been sprayed and kept in the infection chamber twenty-four hours. The results of a number of test experiments are given in Table I. Tap water was used in all cases.

Table I. Shows the approximate percentages of germination of aecidiospores of *Gymnosporangium myricatum* in water cultures.

Date	Method	No. Tests	No. Positive Results	Approximate Percentage of Germination
May 22, 1915	Hanging drop	19	0	0
" 28, "	Petri dish	5	0	0
June 2, "	" "	12	0	0
Mar. 10, 1916	" "	6	0	0
June 10, "	Watch glass	2	1	.4%
" 11, "	" "	6	6	.3%
" 16, "	Petri dish	3	3	.5%
" 16, "	Watch glass	6	5	.2%
" 20, "	Hanging drop	6	0	0
" 20, "	Watch glass	6	6	.5%
" 20, "	Petri dish	3	3	1.0%
" 25, "	Watch glass	3	3	.5%

Where spores are floated on water in watch glasses or Petri dishes a low percentage of germination was obtained. In several cases in which watch glass tests of aecidiospores of both *G. myricatum* and *G. clavariaeforme* were made, the glasses were stacked on one another, and it was found that the spores in the uncovered dish germinated sooner and usually with a higher percentage. The Petri dishes were always set in the damp chamber, and without cover, so that there was an unlimited supply of air. Under these favorable conditions the spores begin to germinate within six or eight hours. Leaves bearing aecidia had been placed in cheesecloth bags and hung outside the greenhouse all winter; spores from these leaves did not germinate in Petri dish cultures when tried the following March, as shown in the above table.

In June, 1916, germination tests were made of aecidiospores of several other species of *Gymnosporangium*. There is the greatest variation in the behavior of the different species. *G. globosum* showed the lowest percentage, not over 0.1 per cent.; *G. juvenescens* up to 10 per cent.; *G. nidus-avis* occasionally as high as 50 per cent.; *G. clavariaeforme* invariably gave 95–100 per cent. germination if the watch glasses were left uncovered in the damp chamber.

The salmon color of the spores of *Aecidium myricatum* is due, as in many other spore forms, to the color of the spore contents.

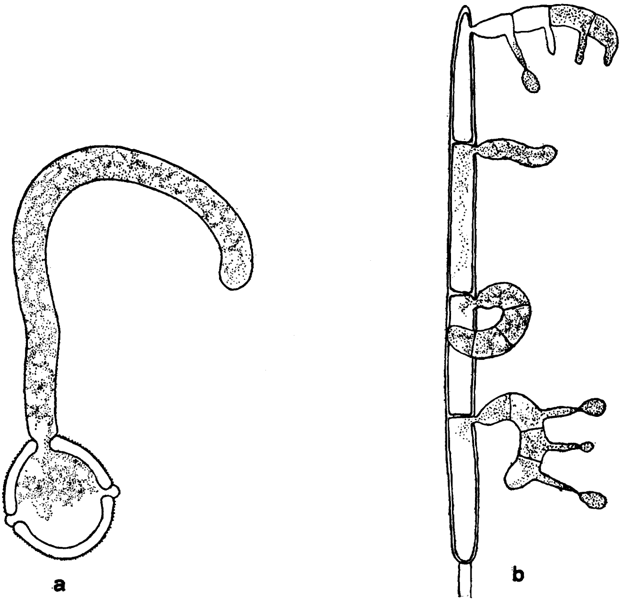

FIG. 1. *a.* Aecidiospore of *Gymnosporangium myricatum* twenty-two hours after the beginning of the germination test experiment. Three germ pores appear in one plane. Most of the orange-colored contents have moved out into the germ tube. × 450. *b.* A germinating teleutospore of *Gymnosporangium myricatum.* × 450.

The germ tube emerges from the germ pore and immediately enlarges considerably (Text-fig. 1, a); it sometimes branches rather irregularly. The wall of the spore is only slightly thickened about the germ pores. The brown color of the spores of the other species of *Gymnosporangium* mentioned above is in the spore wall, and there is, for example, in *G. clavariaeforme* a very prominent thickening of the wall about the spores. Sorauer's figure 50[9] (1906) of a germinating aecidiospore does not adequately bring out these features.

Reed and Crabill (1915) obtained much higher percentages of germination of the aecidiospore of *G. macropus* than we have with *Aecidium myricatum,* yet they assume that the spores may winter over and germinate in the spring, since they were unable to obtain artificial infections of red cedars.

Harshberger (1902) has made a study of the behavior of the mycelium of *G. Ellisii* in the tissues of *Chamaecyparis.* He finds an abundance of intracellular hyphae in the cortex, soft bast, wood cambium and tracheids, as well as in the medullary rays, and believes that the mycelium residing in the wood cambium and soft bast is responsible for the increased thickening of the annular rings. Farlow (1880) has very adequately described this *Gymnosporangium* and figured very characteristically a small witches'-broom and a germinating teleutospore. Our figure 5 in plate 2 shows the sori in the dried conditions. We find that they do not swell up to such a great extent when moistened as do sori of most Gymnosporangia. The promycelia are usually quite sharply bent, as appears in Text-figure 1, b.

The perfection of methods by which seedling cedars may be easily infected should afford a better opportunity for studying the behavior of both the host and the fungus in their mutual relationships. The evidence is suggestive that *G. myricatum* also go to the sweet fern, but in view of the very complex interrelations which have so far been found between the hosts of the species of *Gymnosporangium* and their roesteliae, a positive conclusion can only be reached by actually demonstrating the infection of the sweet fern by *G. Ellisii.*

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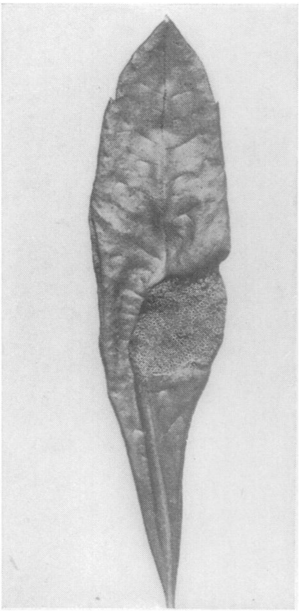

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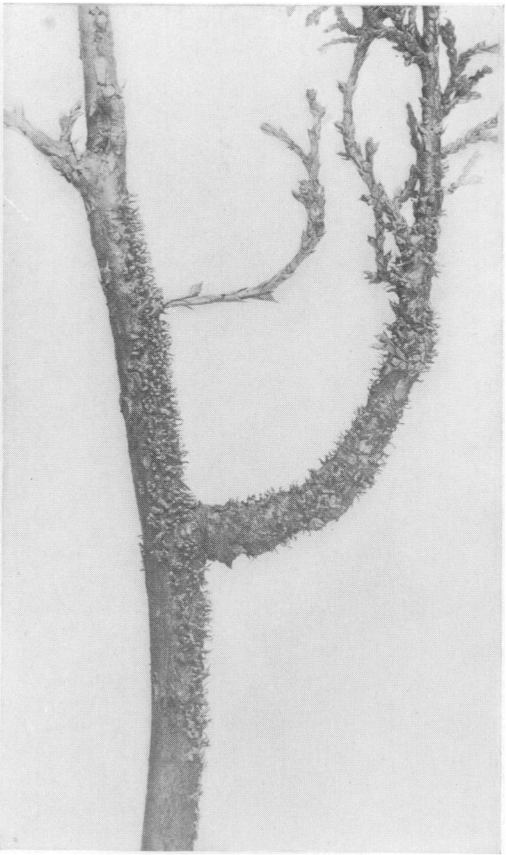

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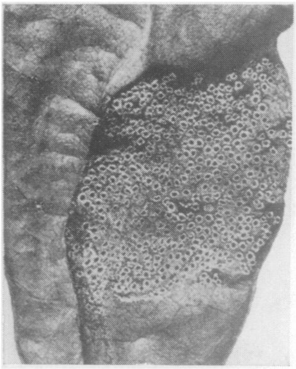

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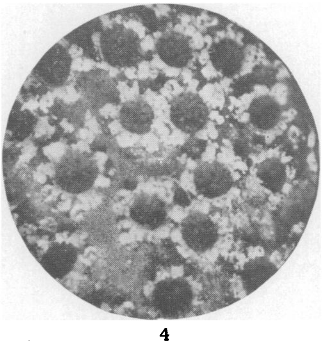

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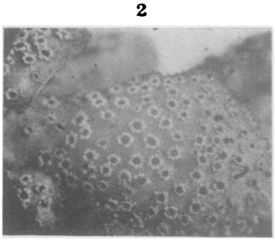

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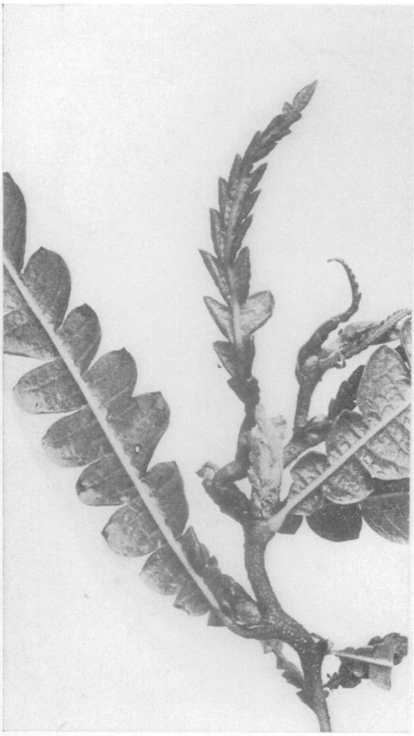
GYMNOSPORANGIUM ELLISII—AECIDIUM MYRICATUM



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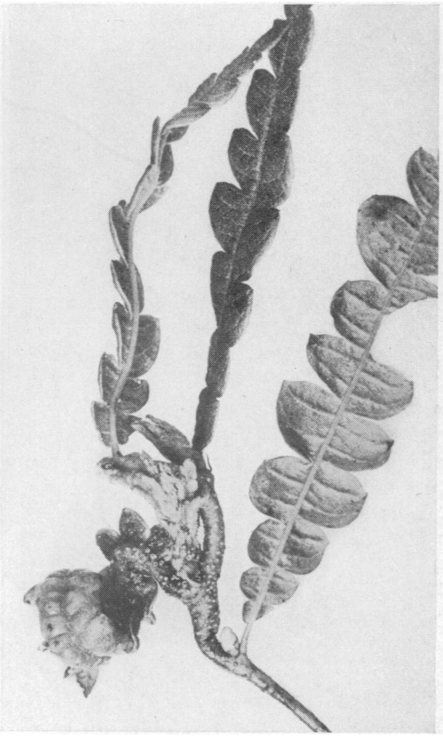

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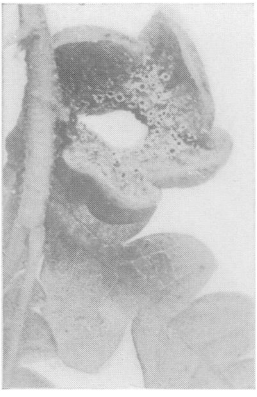

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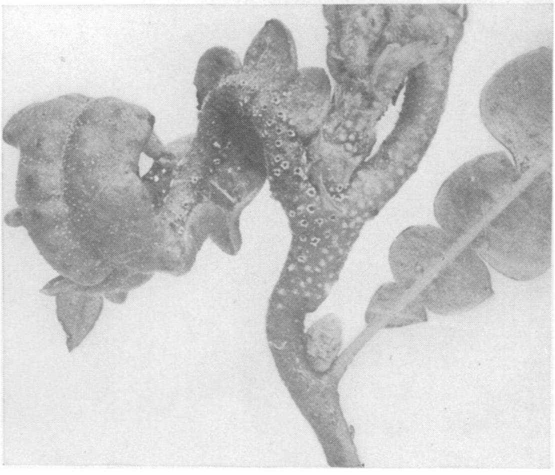

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RUST ON COMPTONIA ASPLENIFOLIA

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EXPLANATION OF PLATES

PLATE 2. GYMNOSPORANGIUM ELLISII—AECIDIUM MYRICATUM

Fig. 1. Leaf of *Myrica carolinensis* infected at one point showing crowded aecidia. Natural size.

Fig. 2. Portion of the same leaf. × 2¼.

Fig. 3. A group of aecidia from an infected bud. × 5.

Fig. 4. A number of aecidia showing the white, recurved, peridial segments. × 20.

Fig. 5. A small witches'-broom on *Chamaecyparis* showing numerous teleutospore sori in the dry condition. About natural size.

PLATE 3. RUST ON COMPTONIA ASPLENIFOLIA

Fig. 1. Twig and bud infected; aecidia just beginning to show. Natural size.

Fig. 2. Infected leaf coiled up; aecidia scattered sparingly on under side and along the branch which is also infected for some distance.

Fig. 3. Another leaf showing that the lobes and midrib portion are much thickened. Peridial segments broken away and lying about on the leaf surface. × 2.

Fig. 4. Portion of the same branch shown in Fig. 2. The white spots show where aecidia are forming. × 2.